STATUS OF LEVEL 2

AIRS SCIENCE TEAM MEETING

October 21-23, 2003

JOEL SUSSKIND, JOHN BLAISDELL, RYAN CAVENEY
EMMANUEL DADSON, LENA IREDELL, FRICKY KEITA,
LOU KOUVARIS, GYULA MOLNAR

NASA GSFC
Sounder Research Team

TOPICS

- Results using GSFC Version 3.1.8
- Results using latest base line run
- Preliminary results using “noise reduction”

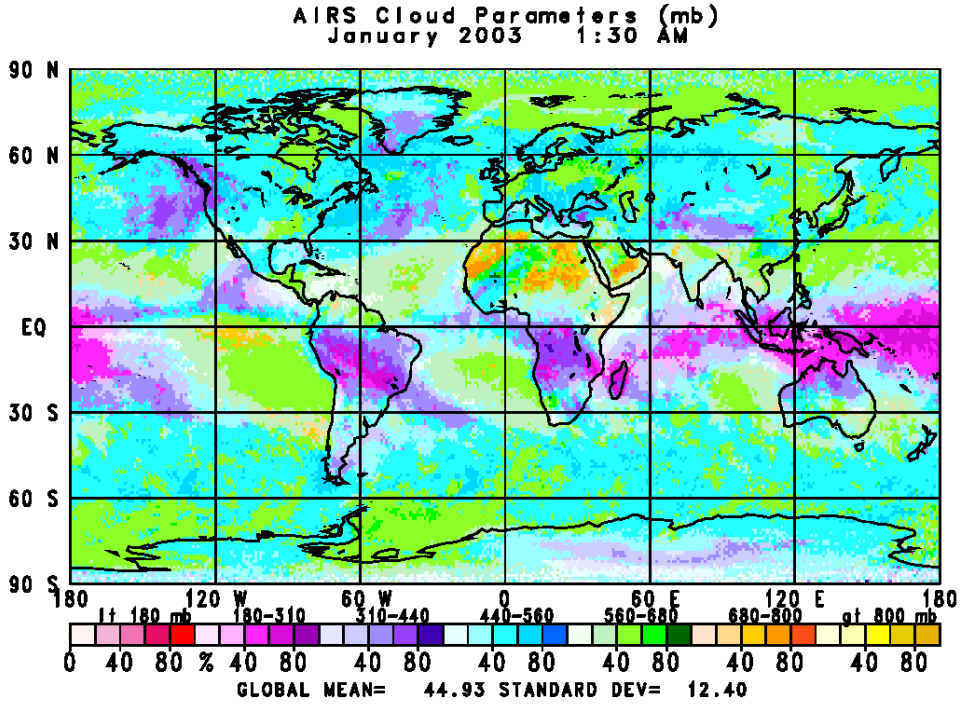
GSFC VERSION 3.1.8

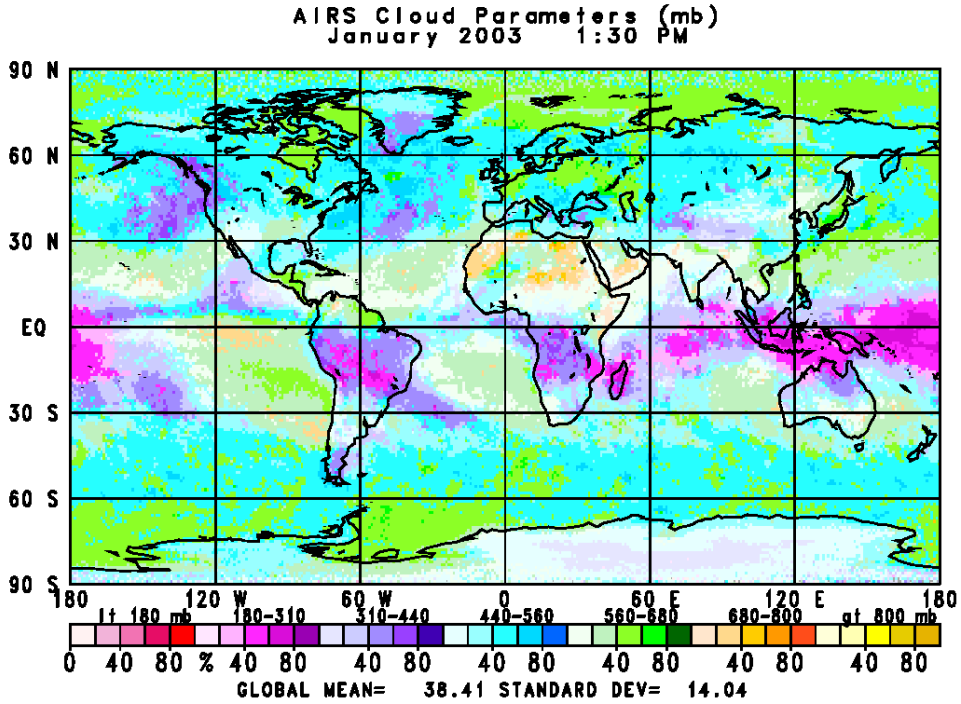
Used to analyze all of January 2003

- Products given to Bob Atlas for forecast impact test
- Monthly mean values compared to ECMWF

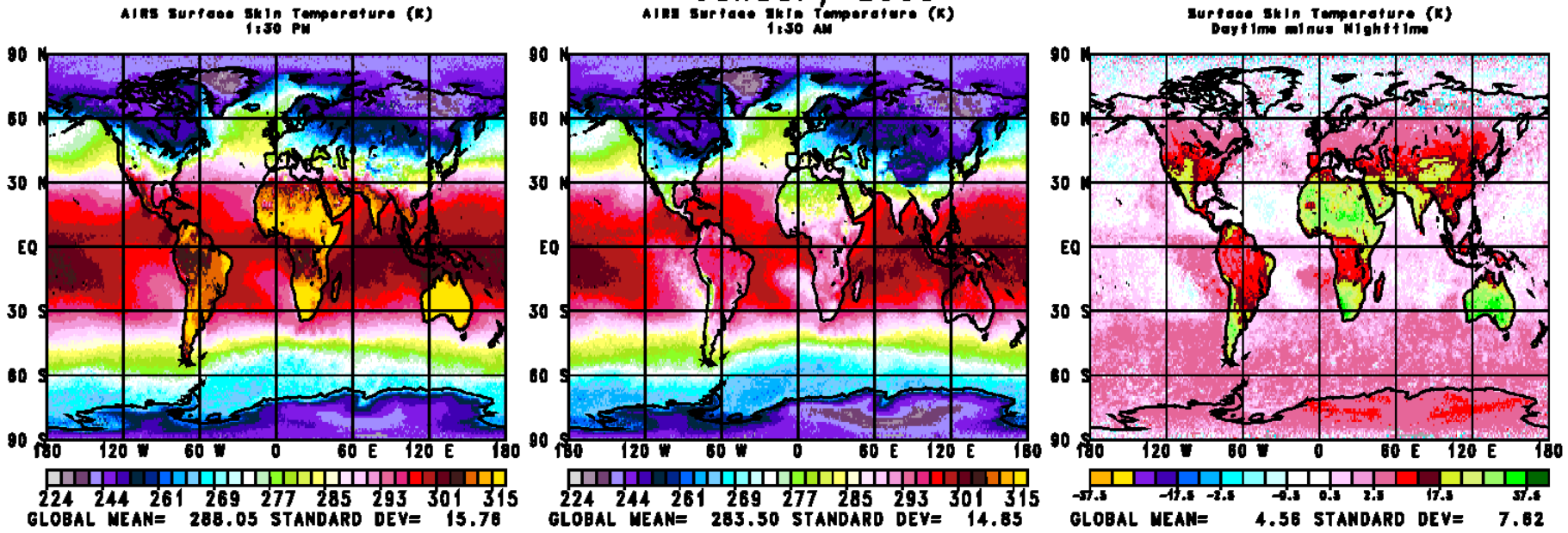
Differences between GSFC Version 3.1.8 and JPL Version 3.1.9

- Treatment of AIRS radiances for channels flagged bad
- Different regression coefficients - need because of above
- Rejection thresholds are different in microwave retrieval
  - GSFC Version accepts more cases over very cold surfaces
- GSFC Version does not check for sunglint


AIRS Cloud Parameters (mb)
January 2003 1:30 AM
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180
120 W
60 W
0
60 E
120 E
180
lt 180 mb
180-310
310-440
440-560
560-680
680-800
gt 800 mb
0 40 80 % 40 80 40 80 40 80 40 80 40 80 40 80
GLOBAL MEAN= 44.93 STANDARD DEV= 12.40

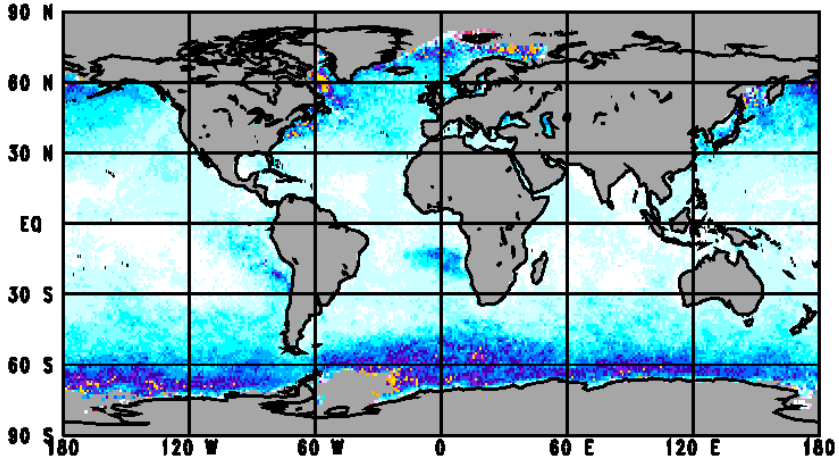

AIRS Cloud Parameters (mb)
January 2003 1:30 PM
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180
120 W
60 W
0
60 E
120 E
180
lt 180 mb
180-310
310-440
440-560
560-680
680-800
gt 800 mb
0 40 80 % 40 80 40 80 40 80 40 80 40 80 40 80
GLOBAL MEAN= 38.41 STANDARD DEV= 14.04

Surface Skin Temperature (K)
January 2003



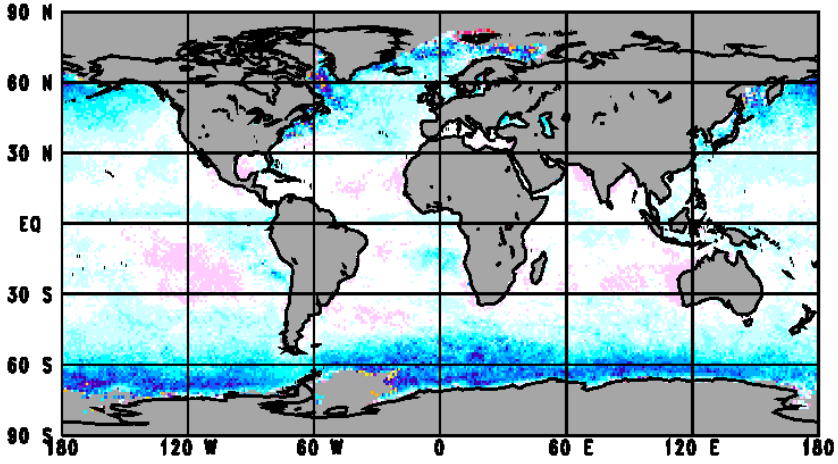
Sea Surface Temperature (K)
January 2003

Sea Surface Temperature (K)
AIRS minus ECMWF



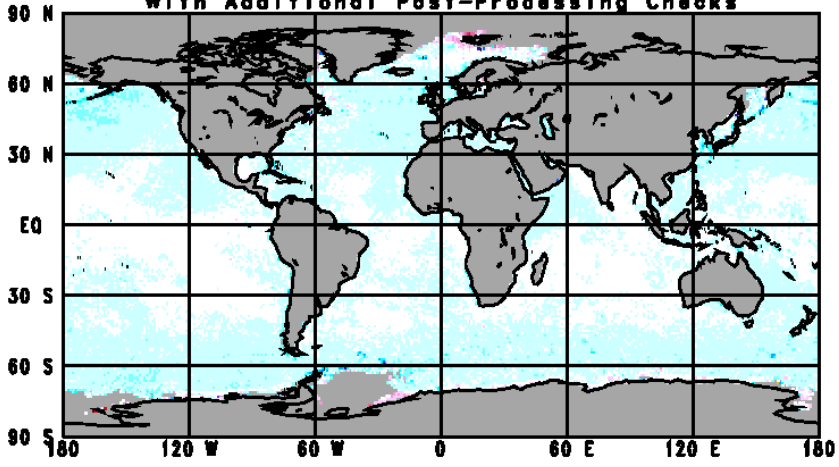
GLOBAL MEAN= -1.65 STD= 1.34 CORR= 1.00

Sea Surface Temperature (K)
AIRS First Product minus ECMWF



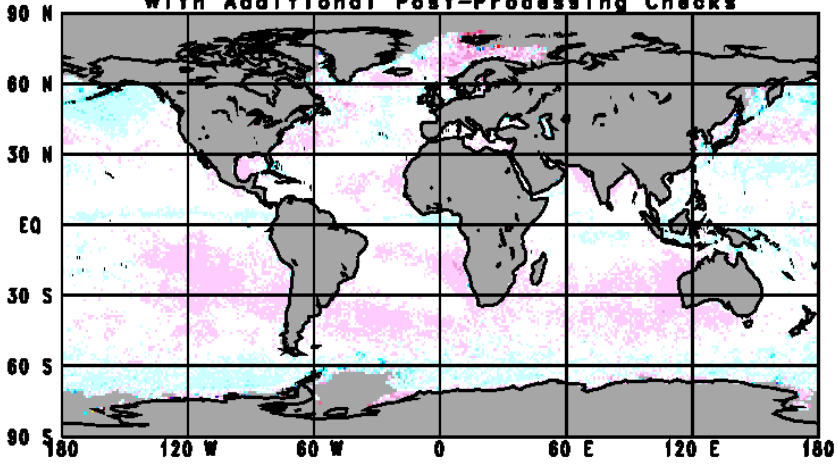
GLOBAL MEAN= -0.84 STD= 1.16 CORR= 1.00

Sea Surface Temperature (K)
AIRS minus ECMWF
With Additional Post-Processing Checks



GLOBAL MEAN= -0.59 STD= 0.45 CORR= 1.00

Sea Surface Temperature (K)
AIRS First Product minus ECMWF
With Additional Post-Processing Checks

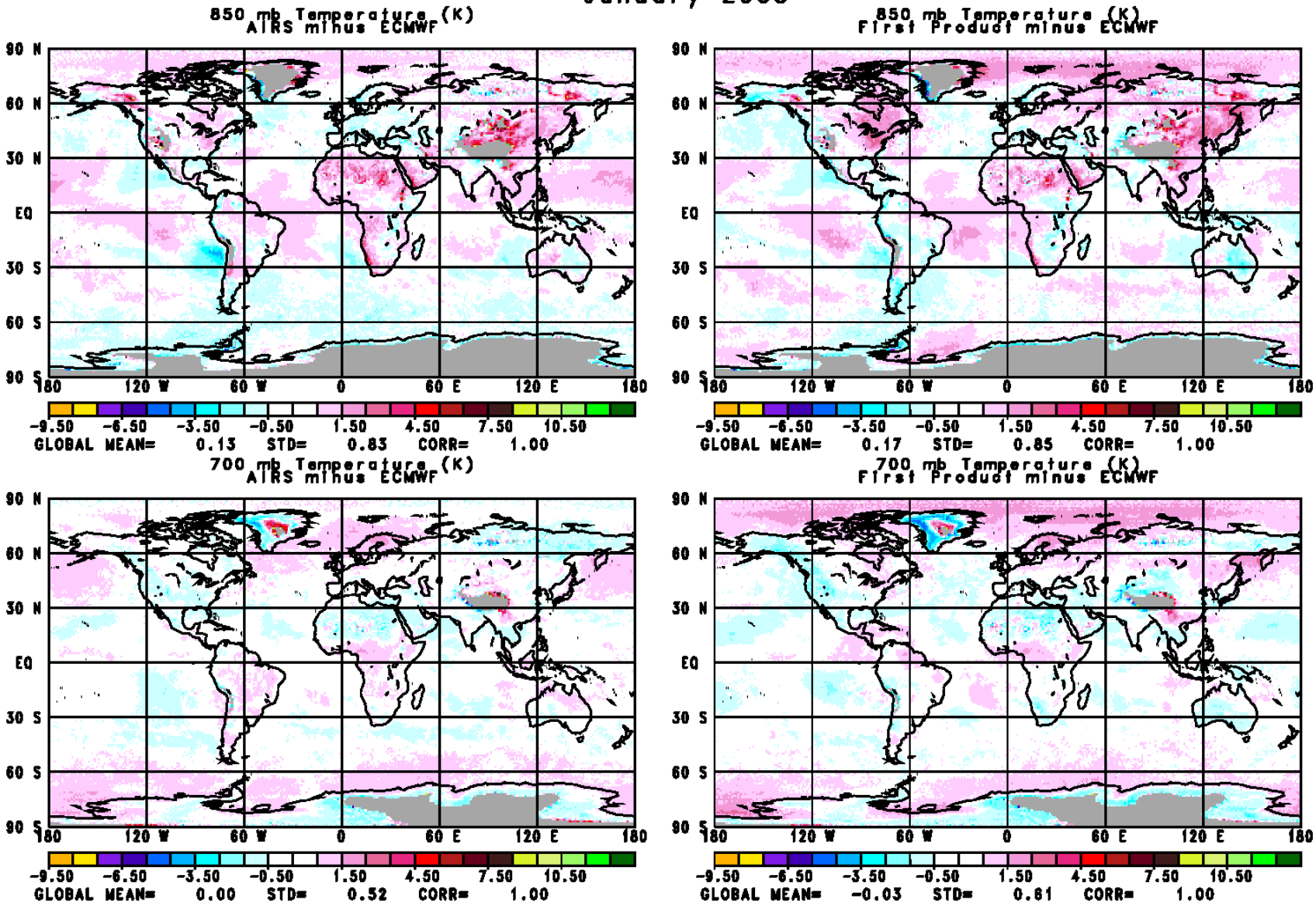


GLOBAL MEAN= 0.05 STD= 0.52 CORR= 1.00

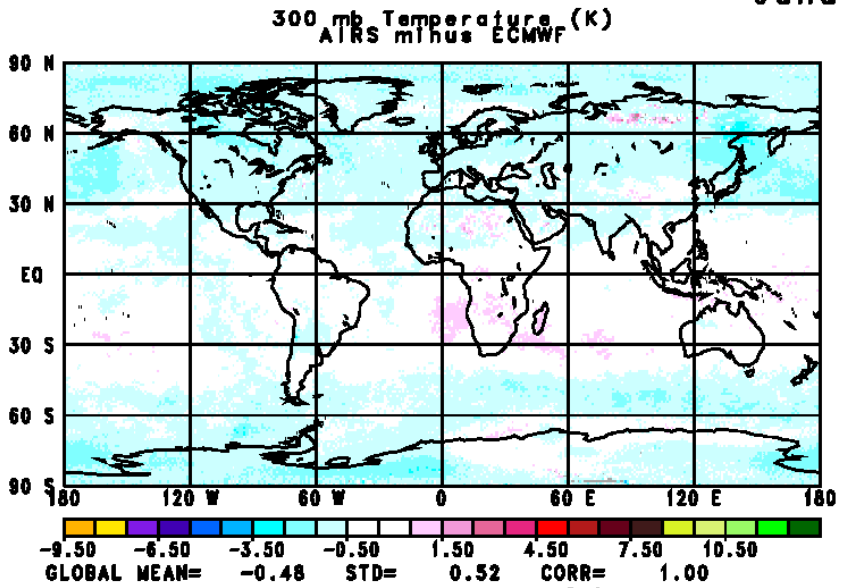
GLOBALLY MONTHLY MEAN TEMPERATURE DIFFERENCE FROM ECMWF

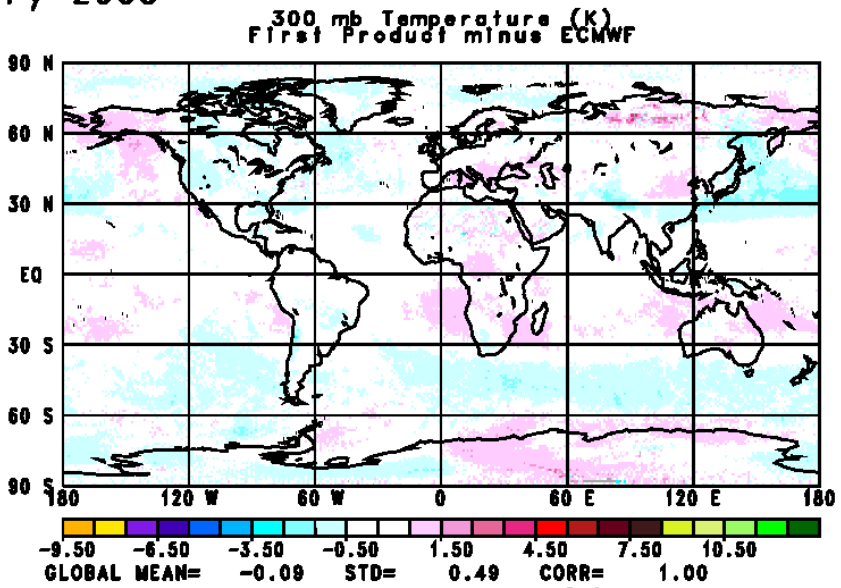
MEAN			STD DEV	
Pressure Level	Retrieved-ECMWF	First-ECMWF	Retrieved-ECMWF	First-ECMWF
850	0.13	0.17	0.83	0.85
700	0.00	-0.03	0.52	0.61
600	0.14	0.01	0.60	0.57
500	0.18	0.00	0.55	0.49
400	0.17	-0.06	0.43	0.41
300	-0.48	-0.09	0.52	0.49
200	-0.04	0.17	0.40	0.52
150	0.18	-0.06	0.62	0.54
100	-0.38	-0.42	0.62	0.69
70	0.02	0.35	0.76	0.80
50	0.06	0.19	0.53	0.62
30	-0.14	-0.22	0.56	0.70
10	0.03	0.29	1.00	0.76

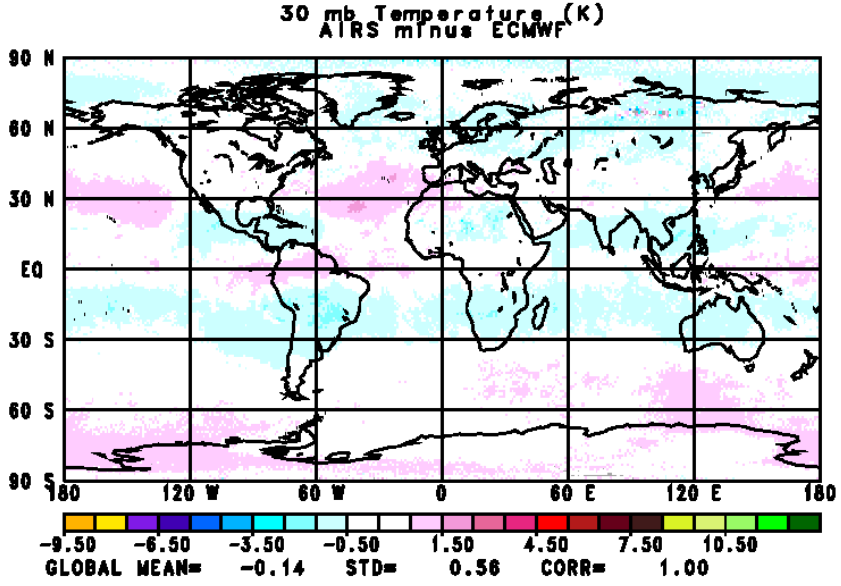
850 mb and 700 mb Temperature (K)
January 2003

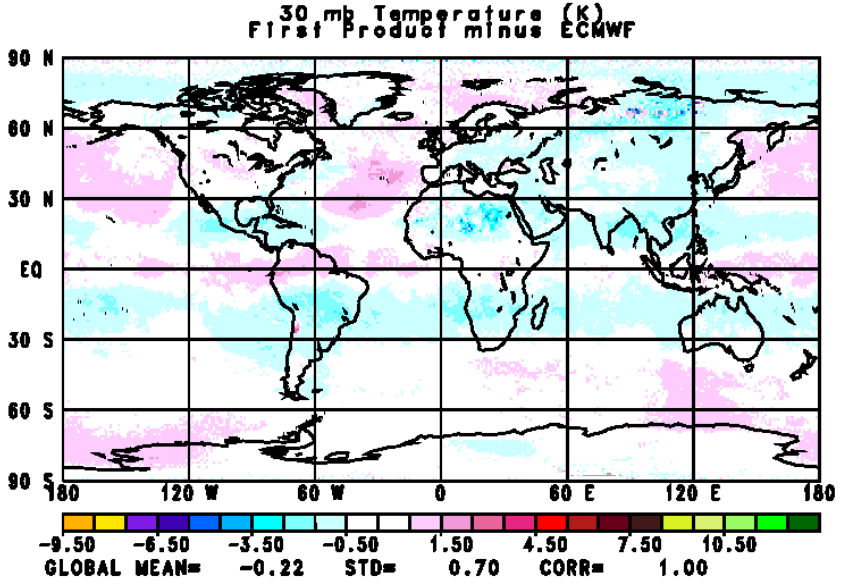


300 mb and 30 mb Temperature (K)
January 2003

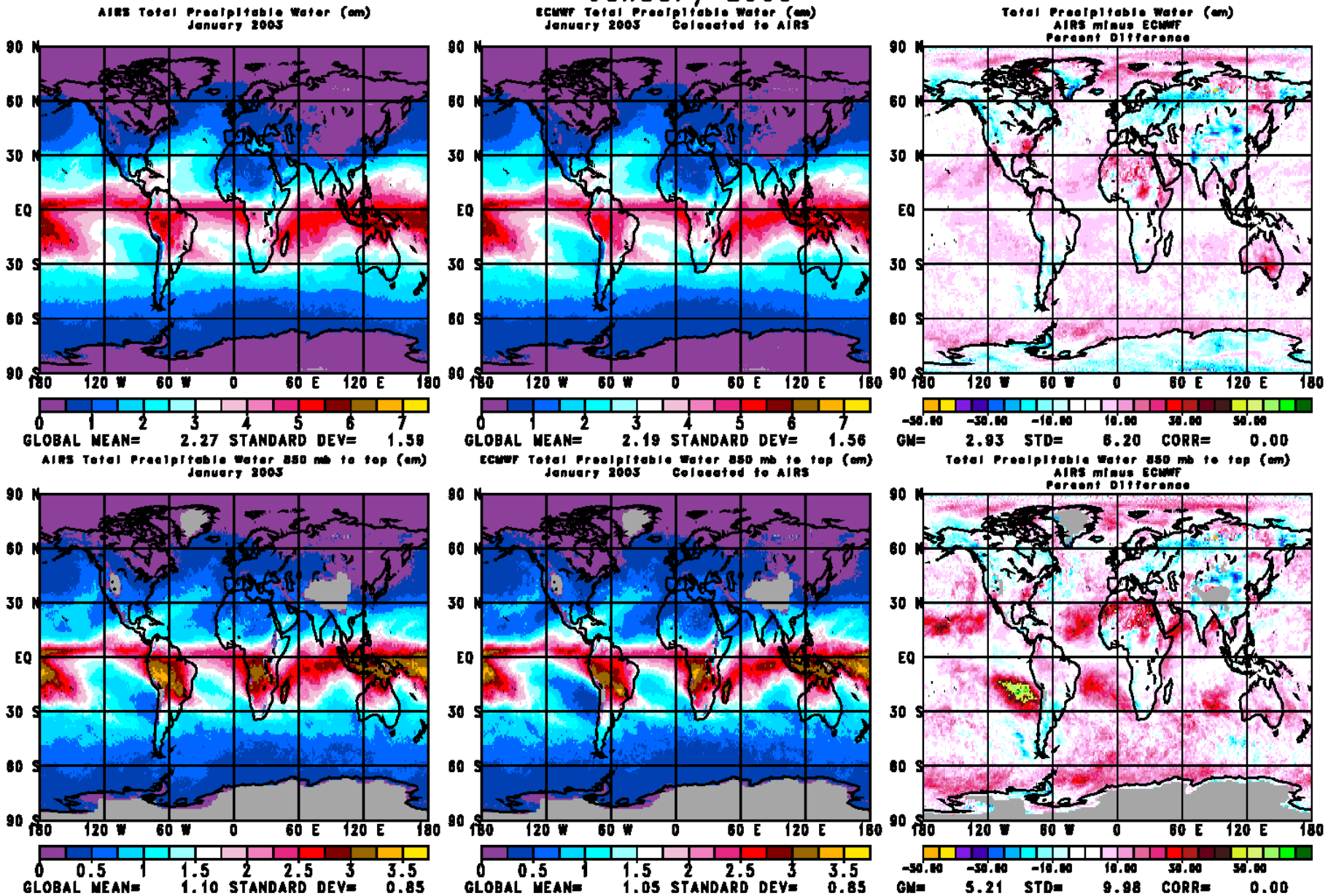






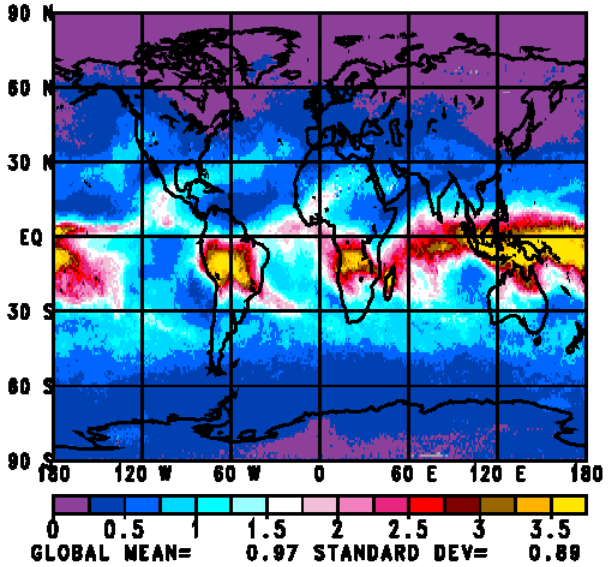


Precipitable Water
January 2003



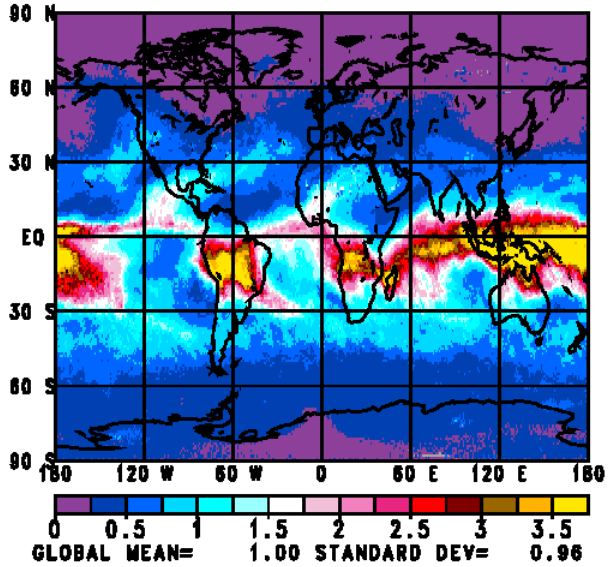
Precipitable Water
Januray 2003

AIRS Total Precipitable Water 500 mb to top (mm)
January 2003



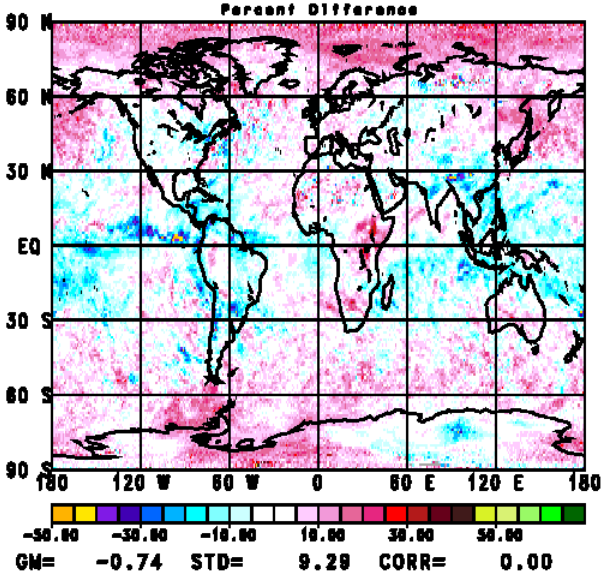
GLOBAL MEAN= 0.97 STANDARD DEV= 0.89

ECMWF Total Precipitable Water 500 mb to top (mm)
January 2003 Colocated to AIRS



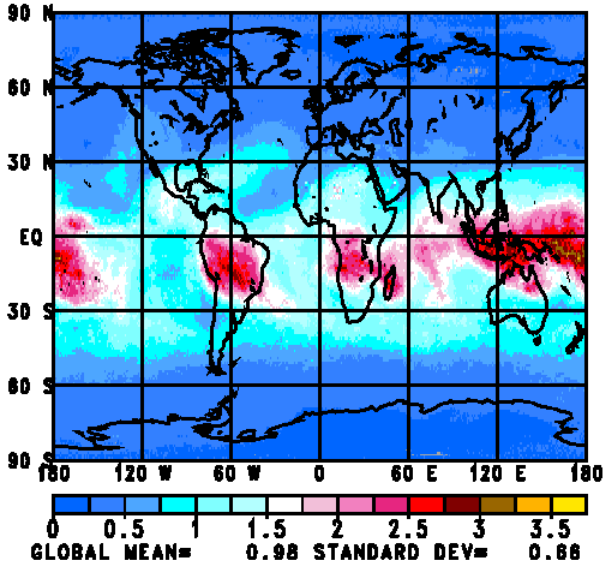
GLOBAL MEAN= 1.00 STANDARD DEV= 0.96

Total Precipitable Water 500 mb to top (mm)
AIRS minus ECMWF
Percent Difference



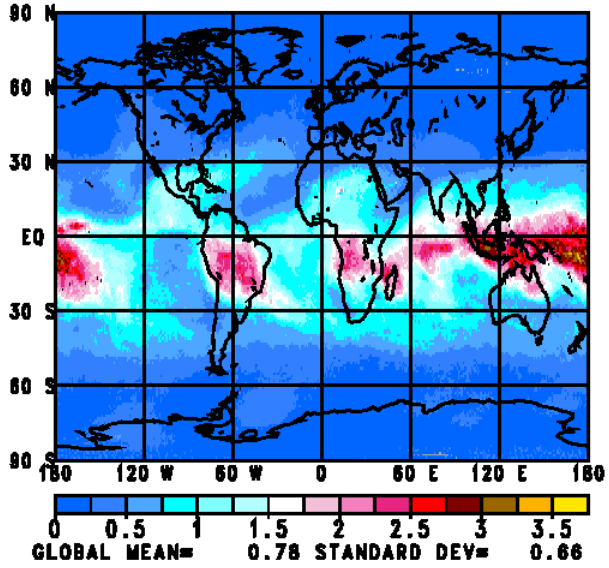
GM= -0.74 STD= 9.29 CORR= 0.00

AIRS Total Precipitable Water 300 mb to top (mm*10)
January 2003



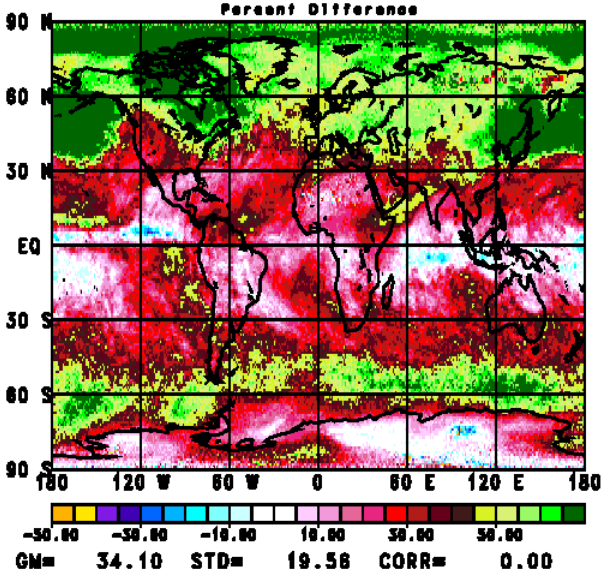
GLOBAL MEAN= 0.98 STANDARD DEV= 0.88

ECMWF Total Precipitable Water 300 mb to top(mm*10)
January 2003 Colocated to AIRS



GLOBAL MEAN= 0.78 STANDARD DEV= 0.66

Total Precipitable Water 300 mb to top (mm*10)
AIRS minus ECMWF
Percent Difference



GM= 34.10 STD= 19.58 CORR= 0.00

RESULTS WITH LATEST BASELINE

Differences from GSFC Version 3.1.8

- Uses latest microwave “tuning error” term from Phil Rosenkranz
- Fixed regression bug for lowest level
- Uses different tuning mask
  - Old tunes 650 cm^{-1} - 756 cm^{-1}, 2182 cm^{-1} - 2423 cm^{-1}
  - New tunes 650 cm^{-1} - 756 cm^{-1}, 2182 cm^{-1} - 2394 cm^{-1}

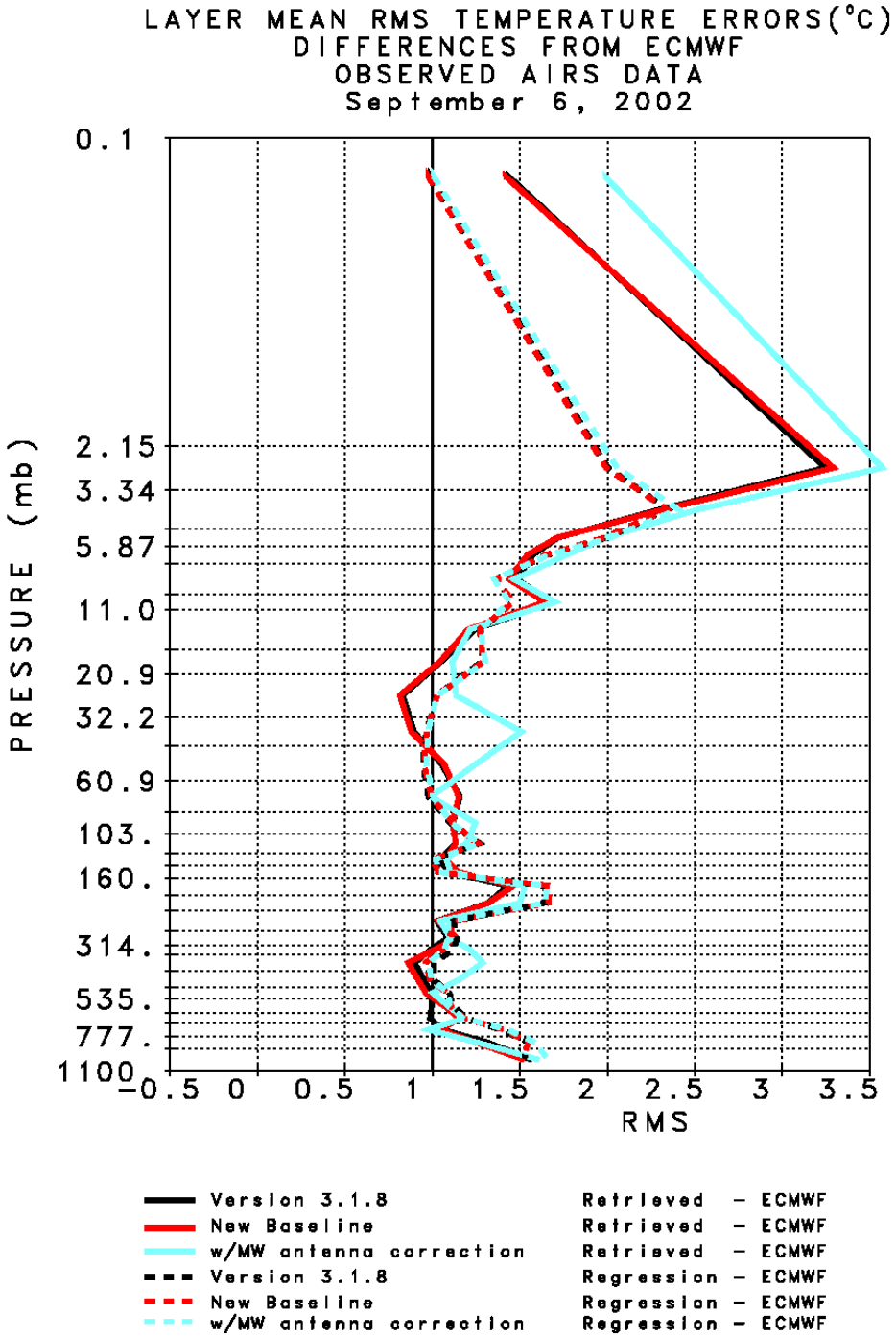
Does not have

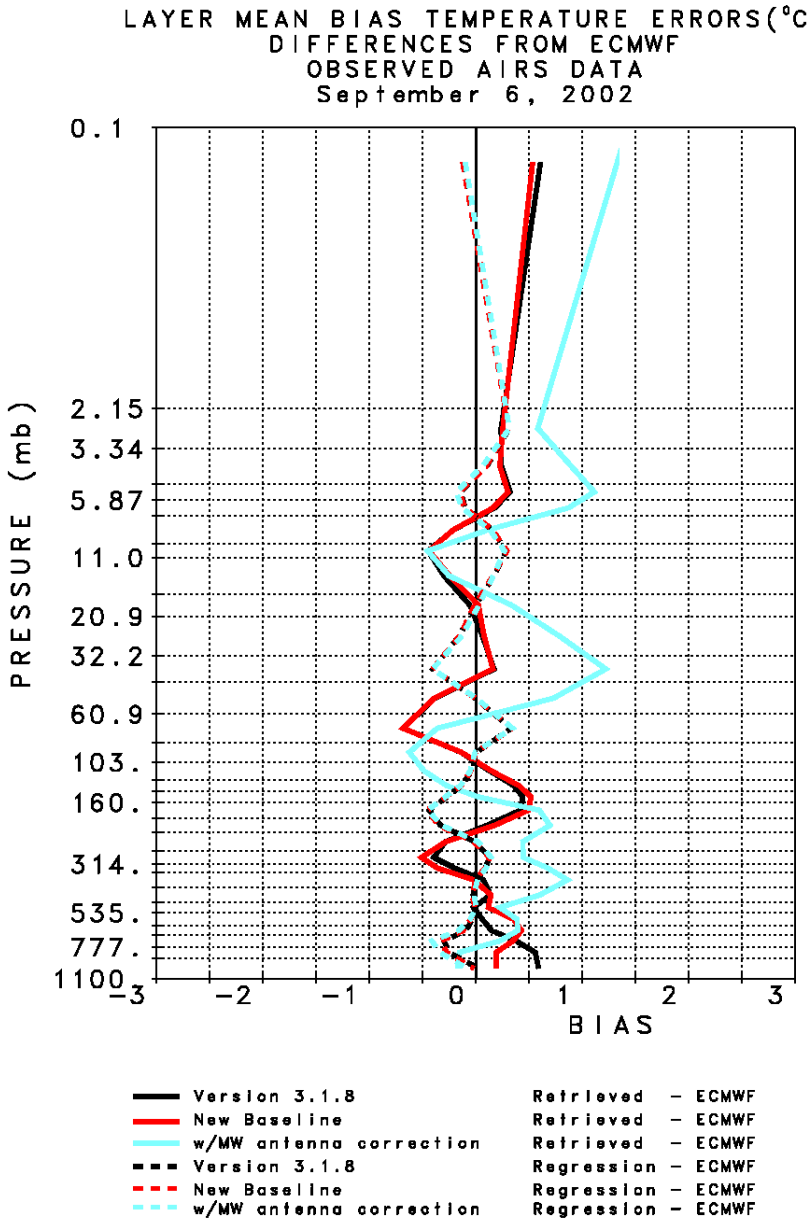
- Changes in IR “tuning error”
  - Experiments still underway
- New treatment of channels flagged bad
  - Not ready to use at GSFC
- Phil Rosenkranz’s new mw physics, retrieval
  - Not ready to use at GSFC

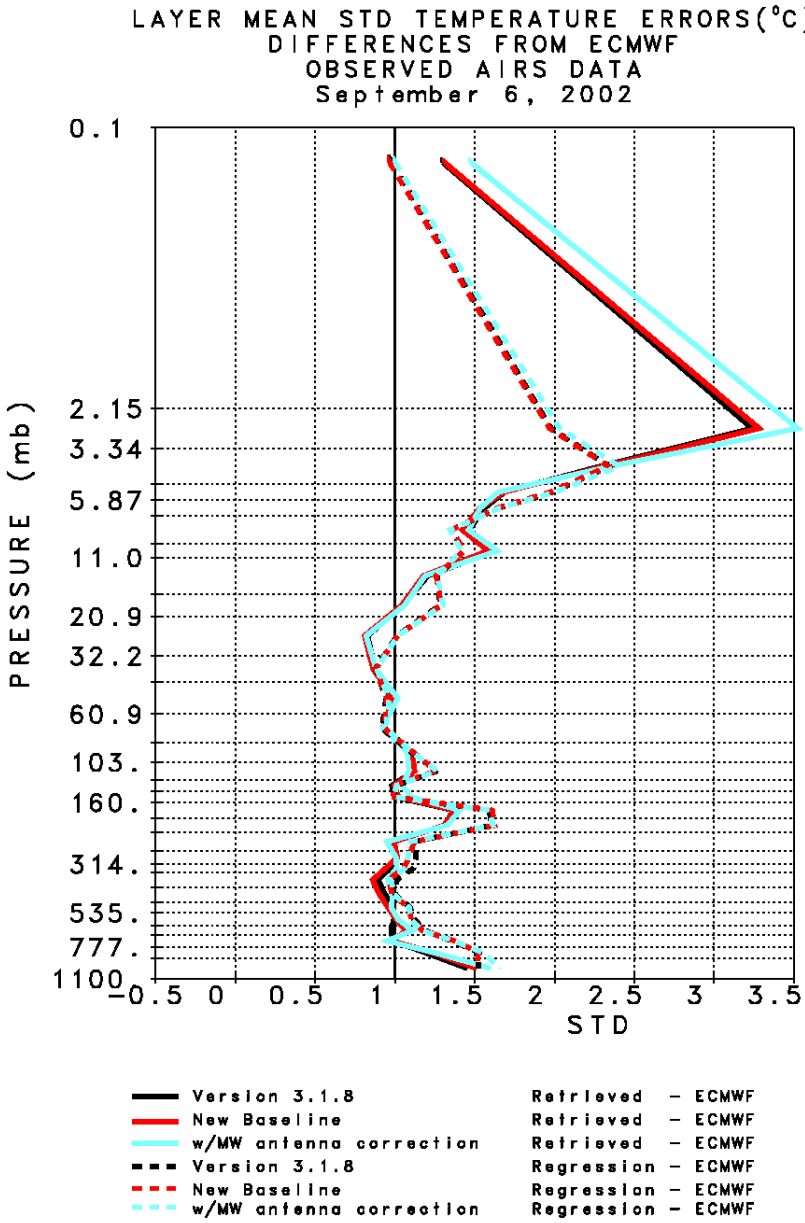
Does not use microwave antenna temperature correction

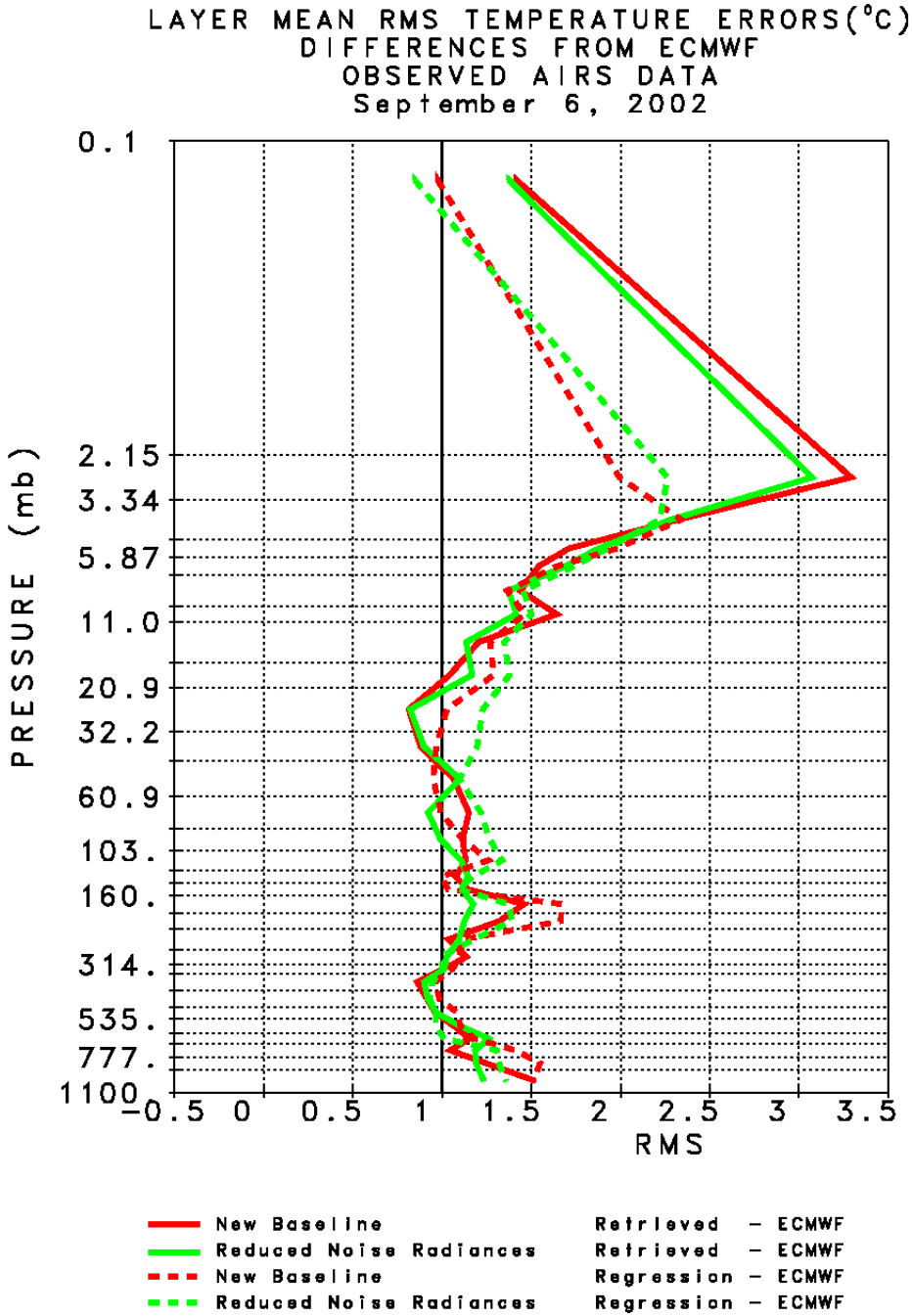
- Retrieval results were very poor

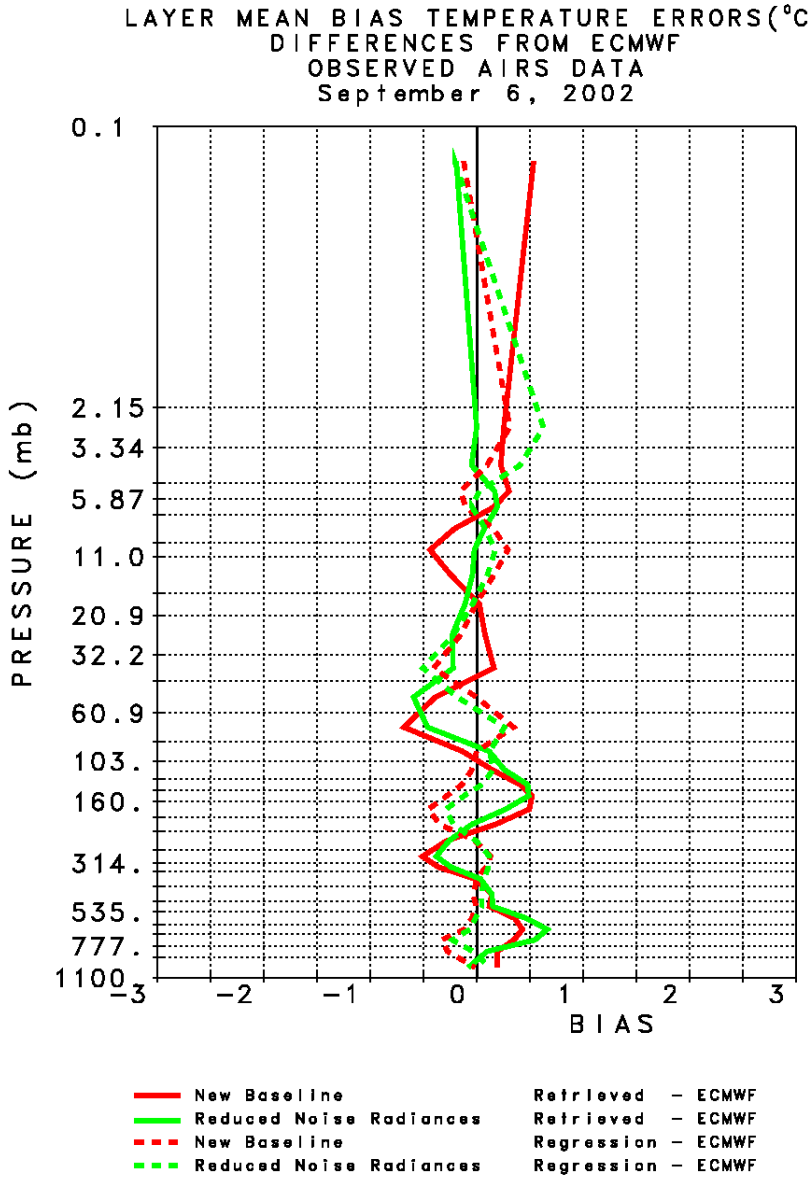
Results shown for 1744 radiosonde colocations on September 6, 2002

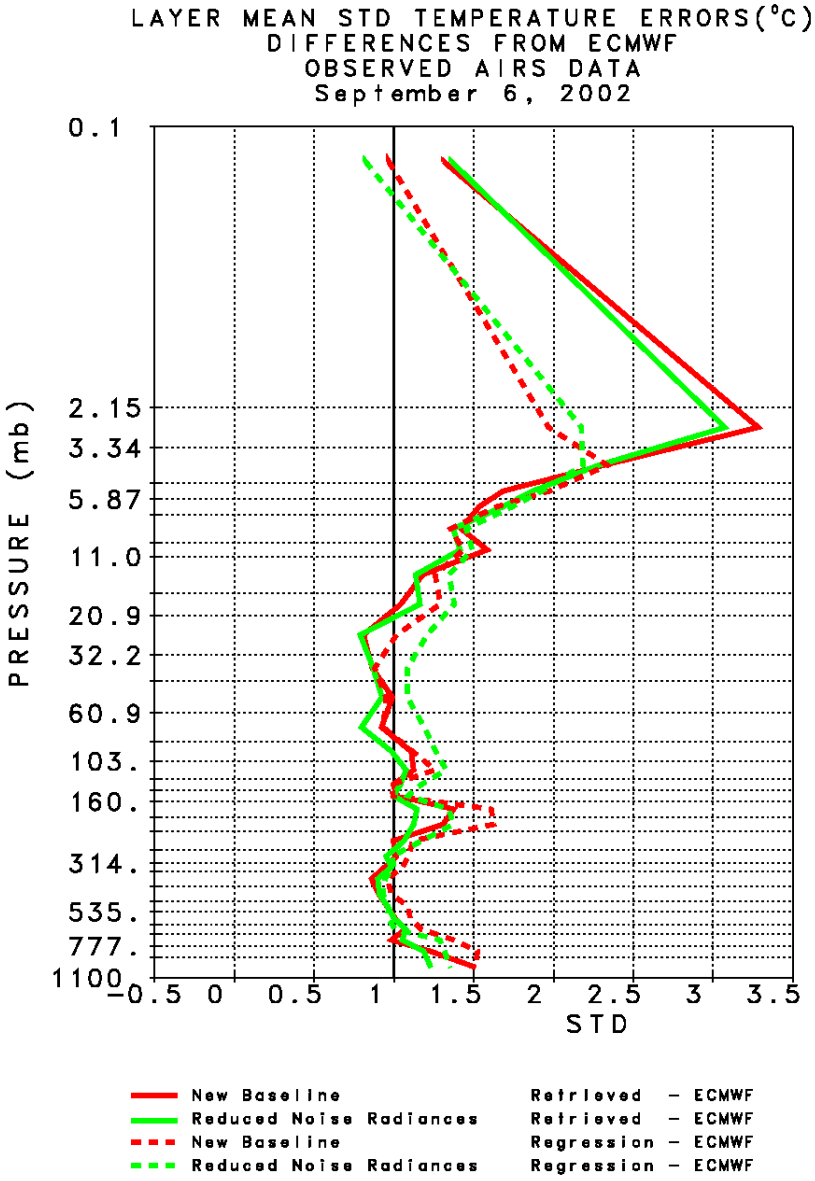

LAYER MEAN RMS TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
RMS
Version 3.1.8 Retrieved - ECMWF
New Baseline Retrieved - ECMWF
w/MW antenna correction Retrieved - ECMWF
Version 3.1.8 Regression - ECMWF
New Baseline Regression - ECMWF
w/MW antenna correction Regression - ECMWF


LAYER MEAN BIAS TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
−3
−2
−1
0
1
2
3
BIAS
Version 3.1.8 Retrieved − ECMWF
New Baseline Retrieved − ECMWF
w/MW antenna correction Retrieved − ECMWF
Version 3.1.8 Regression − ECMWF
New Baseline Regression − ECMWF
w/MW antenna correction Regression − ECMWF


LAYER MEAN STD TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
−0.5
0
0.5
1
1.5
2
2.5
3
3.5
STD
Version 3.1.8 Retrieved − ECMWF
New Baseline Retrieved − ECMWF
w/MW antenna correction Retrieved − ECMWF
Version 3.1.8 Regression − ECMWF
New Baseline Regression − ECMWF
w/MW antenna correction Regression − ECMWF


LAYER MEAN RMS TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
RMS
New Baseline Retrieved – ECMWF
Reduced Noise Radiances Retrieved – ECMWF
New Baseline Regression – ECMWF
Reduced Noise Radiances Regression – ECMWF


LAYER MEAN BIAS TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
−3
−2
−1
0
1
2
3
BIAS
New Baseline Retrieved – ECMWF
Reduced Noise Radiances Retrieved – ECMWF
New Baseline Regression – ECMWF
Reduced Noise Radiances Regression – ECMWF


LAYER MEAN STD TEMPERATURE ERRORS(°C)
DIFFERENCES FROM ECMWF
OBSERVED AIRS DATA
September 6, 2002
PRESSURE (mb)
0.1
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100
−0.5
0
0.5
1
1.5
2
2.5
3
3.5
STD
New Baseline Retrieved – ECMWF
Reduced Noise Radiances Retrieved – ECMWF
New Baseline Regression – ECMWF
Reduced Noise Radiances Regression – ECMWF

AIRS CHANNEL "NOISE REDUCTION"

There are many more AIRS channel (≈ 2300) than independent pieces of information (≈ 100)

Use of the whole spectrum predicts R_i more accurately than it can be measured

METHOD

Simulate noisy and noise free AIRS radiances $R^N_{i,n}, R^{NF}_{i,n}$ for case n

Find regression relationship

$$\left(R_i^{NF} - \overline{R}_i\right) = \sum_j A_{ij}\left(R_j^N - \overline{R}_j\right)$$

A is block diagonal - LW, MW, SW

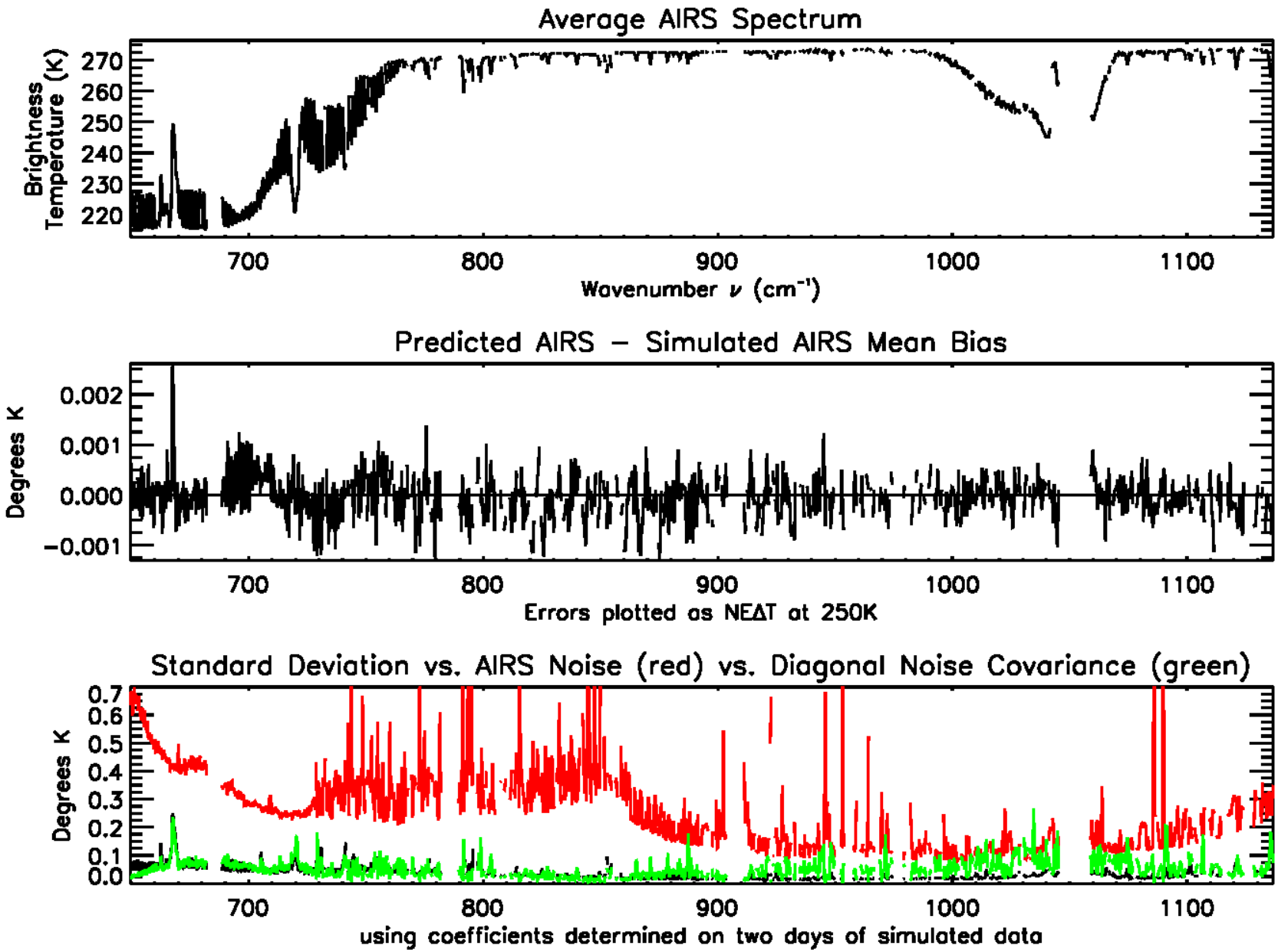
Use as "truth" retrieved state (all parameters including clouds, trace gases, surface emissivity …..) for all accepted retrievals $(\approx 420,000 \text{ cases})$ for September 6, 2002 and January 25, 2003

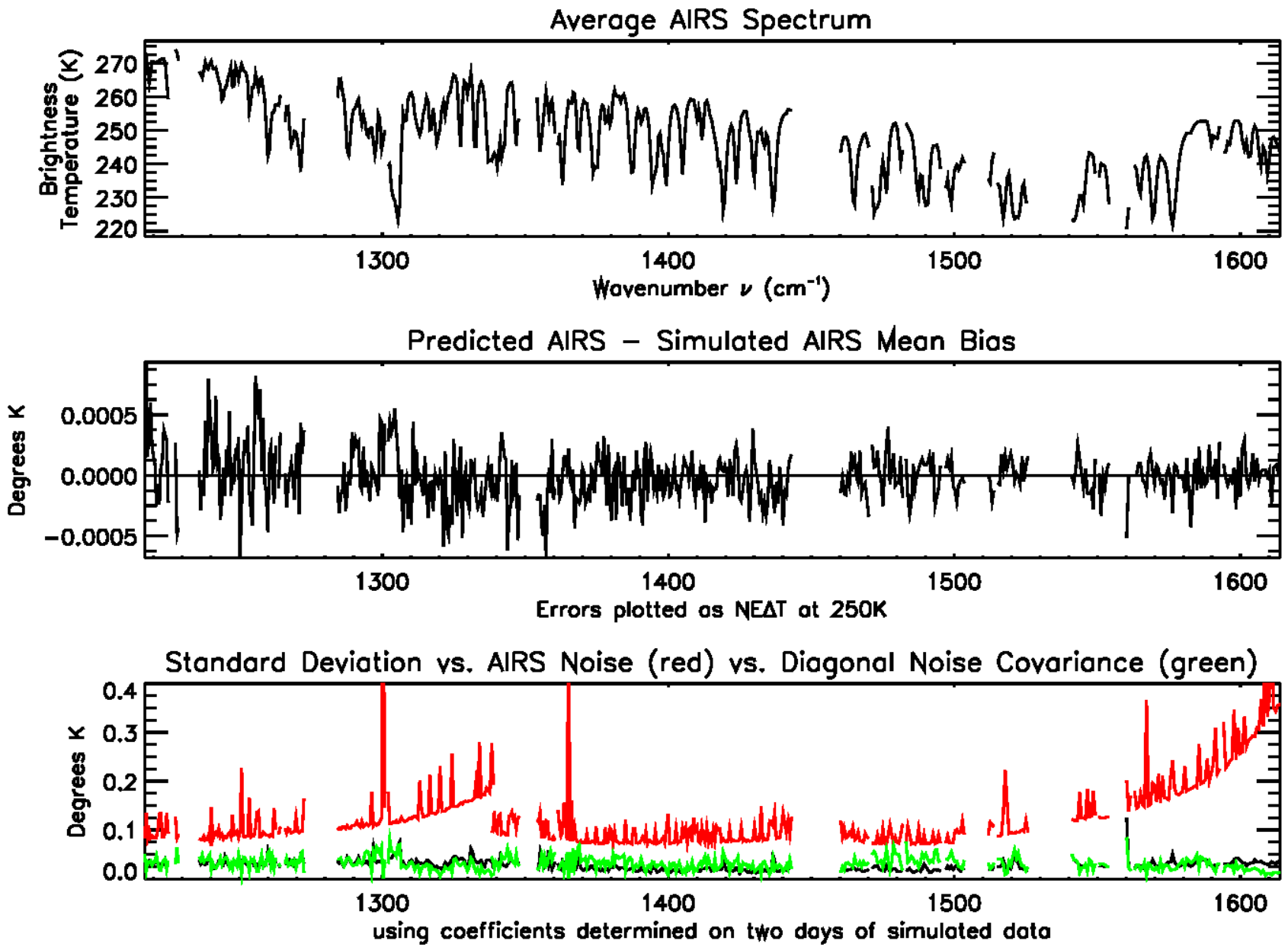
Generate coefficients on 140,000 cases - test on 280,000 cases

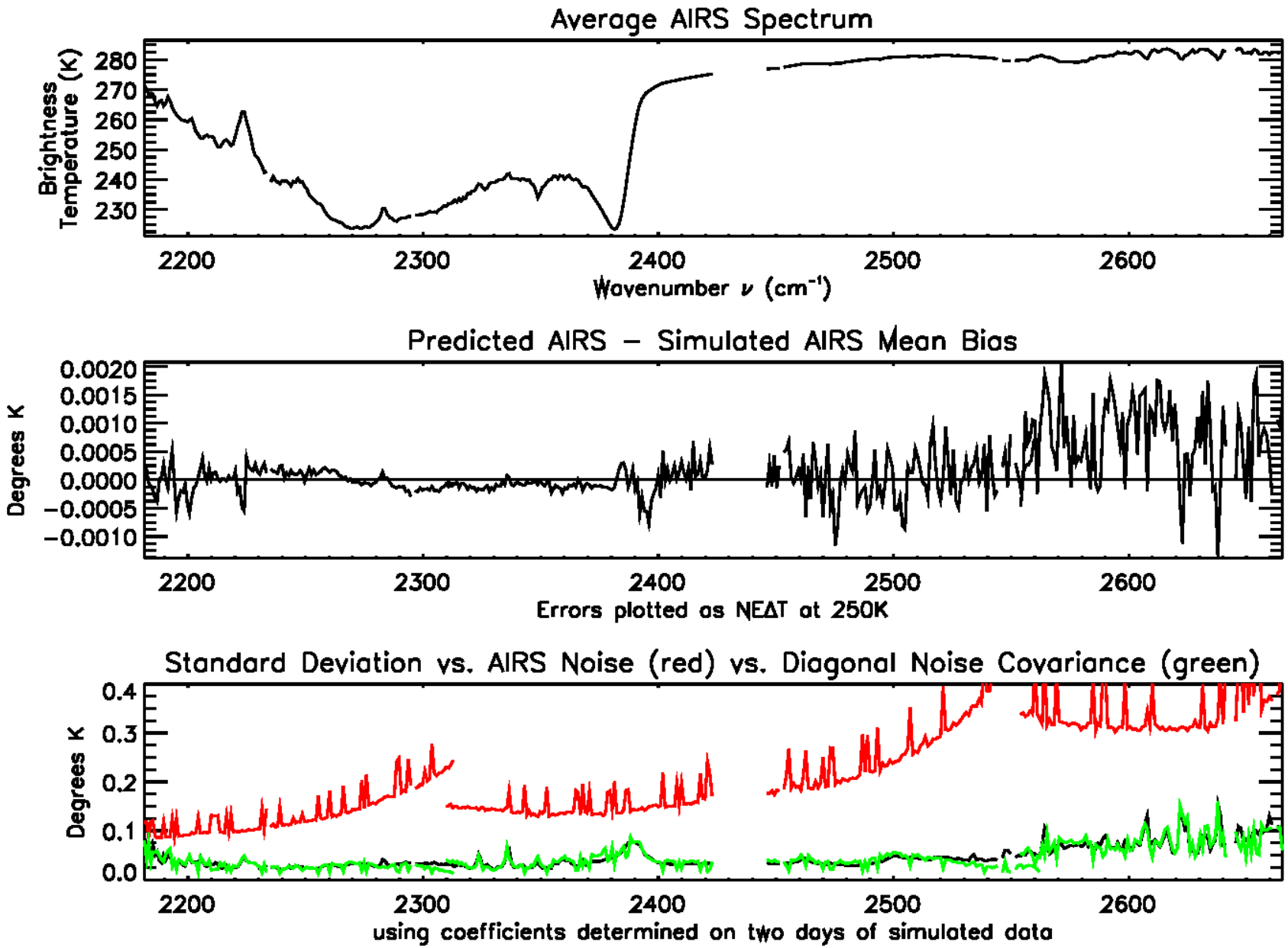
Transformed channel noise covariance matrix N^T

$N^T = ANNA'$ where N is diagonal with original noise

N^T contains off diagonal matrix elements


Average AIRS Spectrum
Brightness Temperature (K)
270
260
250
240
230
220
700
800
900
1000
1100
Wavenumber ν (cm⁻¹)
Predicted AIRS − Simulated AIRS Mean Bias
Degrees K
0.002
0.001
0.000
−0.001
700
800
900
1000
1100
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red) vs. Diagonal Noise Covariance (green)
Degrees K
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
700
800
900
1000
1100
using coefficients determined on two days of simulated data


Average AIRS Spectrum
Brightness Temperature (K)
270
260
250
240
230
220
1300
1400
1500
1600
Wavenumber ν (cm⁻¹)
Predicted AIRS – Simulated AIRS Mean Bias
Degrees K
0.0005
0.0000
−0.0005
1300
1400
1500
1600
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red) vs. Diagonal Noise Covariance (green)
Degrees K
0.4
0.3
0.2
0.1
0.0
1300
1400
1500
1600
using coefficients determined on two days of simulated data


Average AIRS Spectrum
Brightness Temperature (K)
280
270
260
250
240
230
2200
2300
2400
2500
2600
Wavenumber ν (cm⁻¹)
Predicted AIRS − Simulated AIRS Mean Bias
Degrees K
0.0020
0.0015
0.0010
0.0005
0.0000
−0.0005
−0.0010
2200
2300
2400
2500
2600
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red) vs. Diagonal Noise Covariance (green)
Degrees K
0.4
0.3
0.2
0.1
0.0
2200
2300
2400
2500
2600
using coefficients determined on two days of simulated data

REDUCTION OF NOISE WITH OBSERVED DATA

Apply coefficients to all observed data $R_{i,n}$ for September 6, January 25

If $R_{i,n}$ is flagged bad, set $\left(R_{i,n} - \overline{R}_i\right) = 1/2\left[\left(R_{i-i,n} - \overline{R}_{i-1}\right) + \left(R_{i+1,n} - \overline{R}_{i+1}\right)\right]$

Use $R'_{i,n} = A\,R_{i,n}$ in place of $R_{i,n}$ in retrieval program

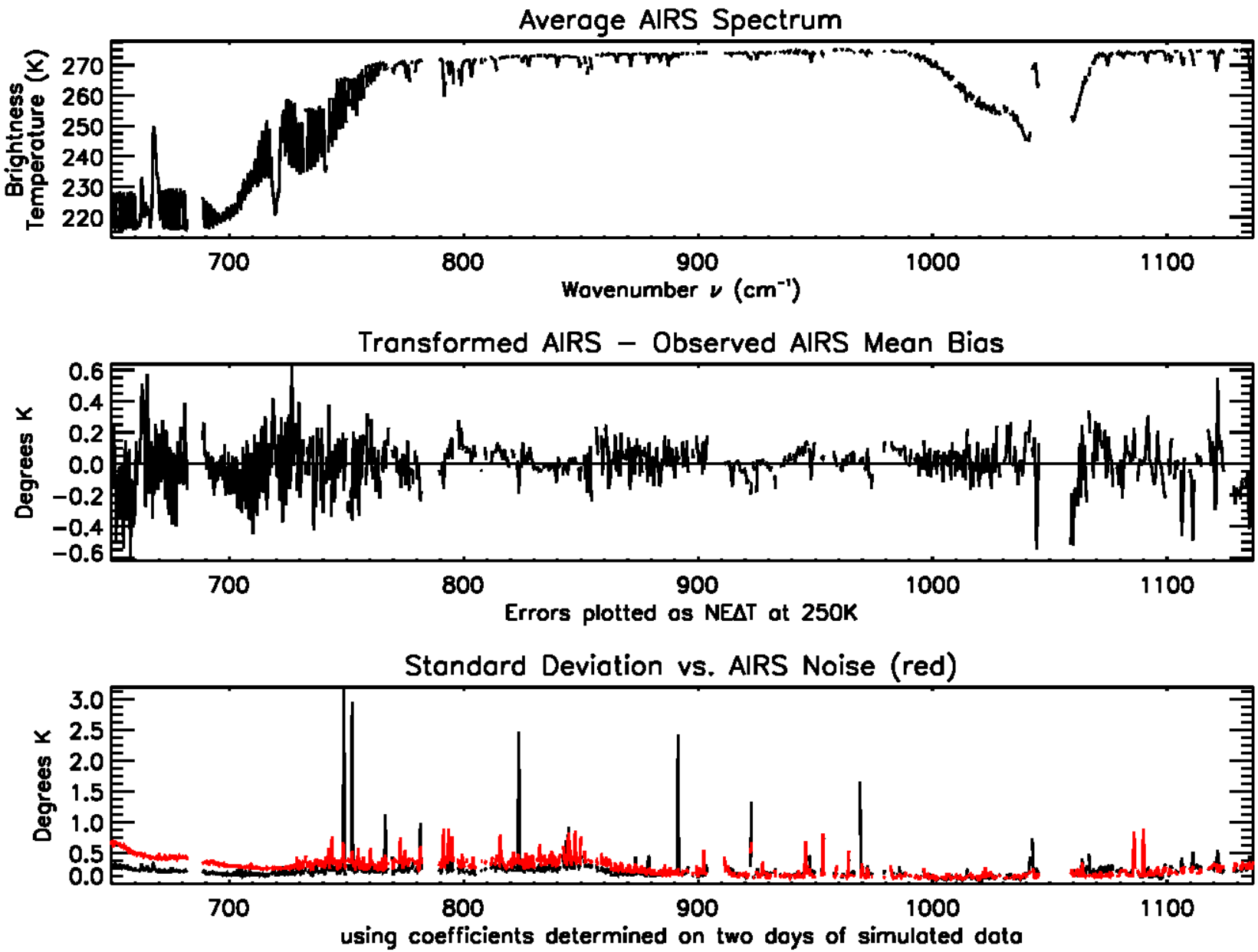
Can set $A_{ij} = \delta_{ij}$ for select channels if you choose to

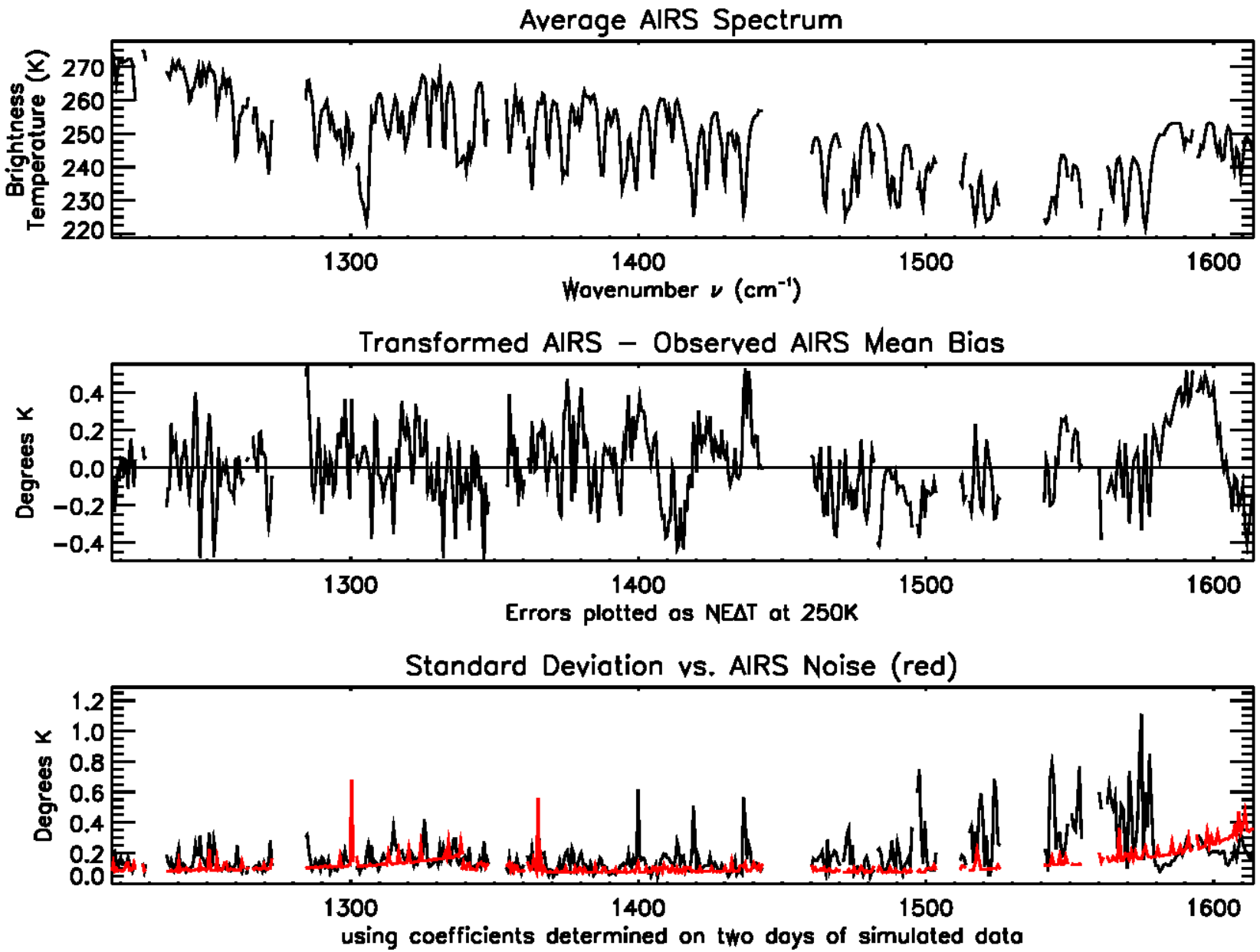
No change needed to retrieval program except for

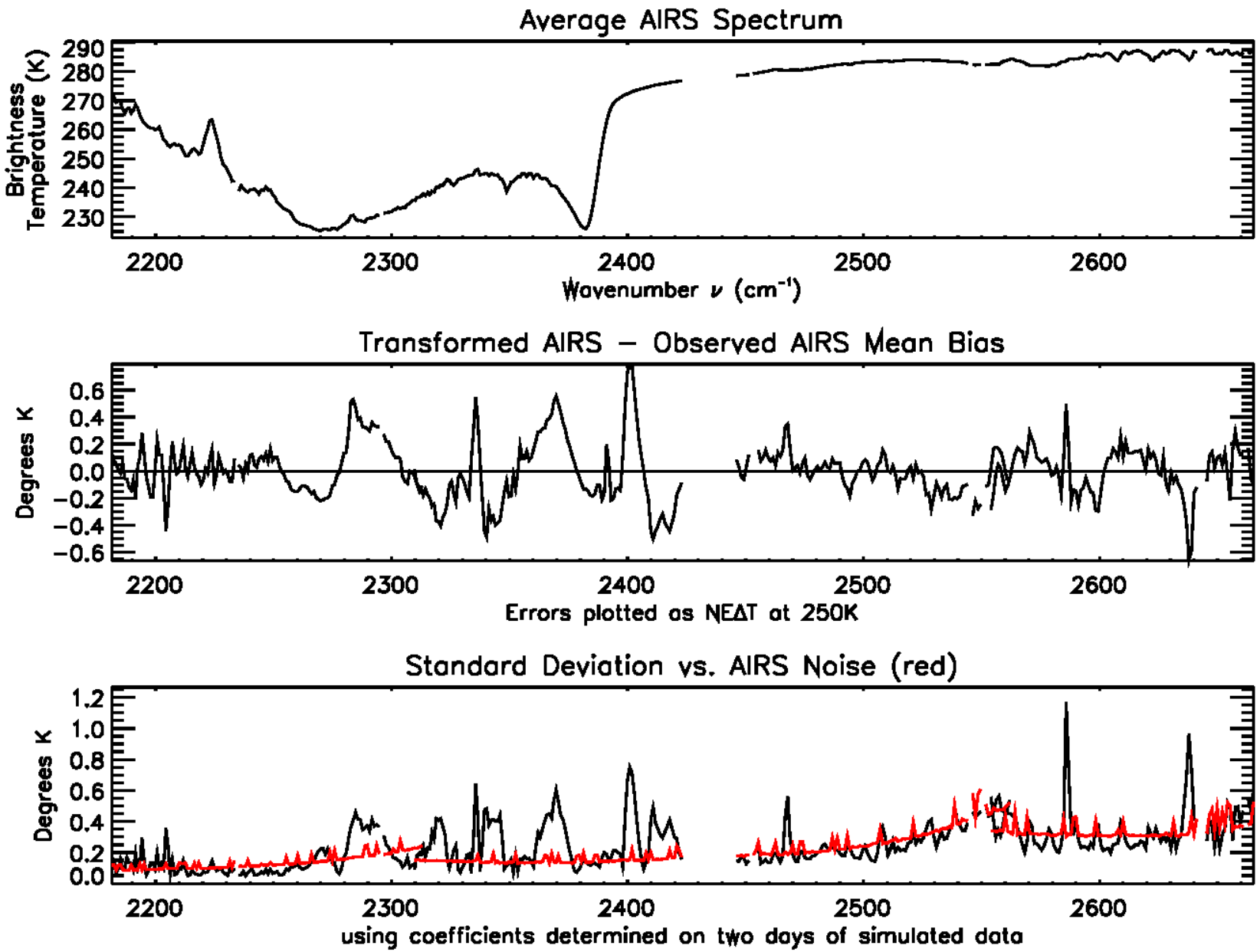
New tuning

New regression

New channel noise covariance matrix


Average AIRS Spectrum
Brightness Temperature (K)
270
260
250
240
230
220
700
800
900
1000
1100
Wavenumber ν (cm⁻¹)
Transformed AIRS – Observed AIRS Mean Bias
Degrees K
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
700
800
900
1000
1100
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red)
Degrees K
3.0
2.5
2.0
1.5
1.0
0.5
0.0
700
800
900
1000
1100
using coefficients determined on two days of simulated data


Average AIRS Spectrum
Brightness Temperature (K)
270
260
250
240
230
220
1300
1400
1500
1600
Wavenumber ν (cm⁻¹)
Transformed AIRS – Observed AIRS Mean Bias
Degrees K
0.4
0.2
0.0
−0.2
−0.4
1300
1400
1500
1600
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red)
Degrees K
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1300
1400
1500
1600
using coefficients determined on two days of simulated data


Average AIRS Spectrum
Brightness Temperature (K)
290
280
270
260
250
240
230
2200
2300
2400
2500
2600
Wavenumber ν (cm⁻¹)
Transformed AIRS – Observed AIRS Mean Bias
Degrees K
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
2200
2300
2400
2500
2600
Errors plotted as NEΔT at 250K
Standard Deviation vs. AIRS Noise (red)
Degrees K
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2200
2300
2400
2500
2600
using coefficients determined on two days of simulated data

FIRST EXPERIMENT RUN WITH NOISE REDUCED RADIANCES

Used $R_i' = AR$ for all channels

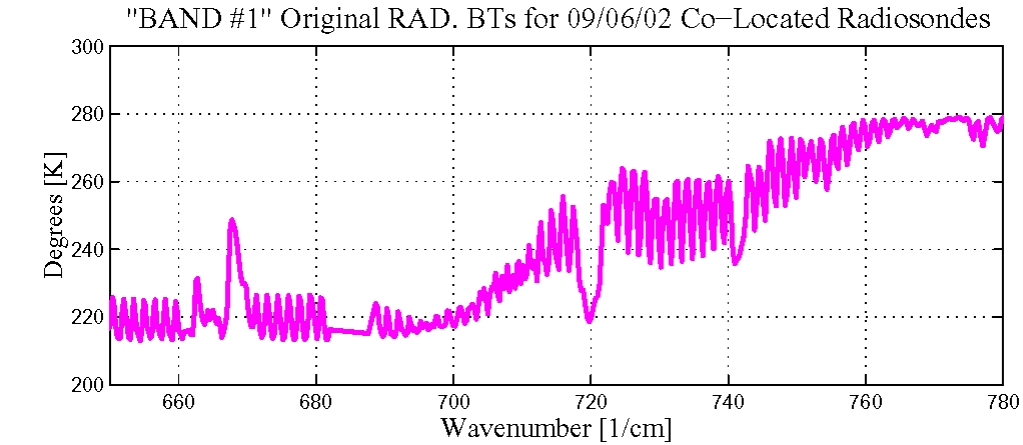
Generated new tuning coefficients, regression matrix

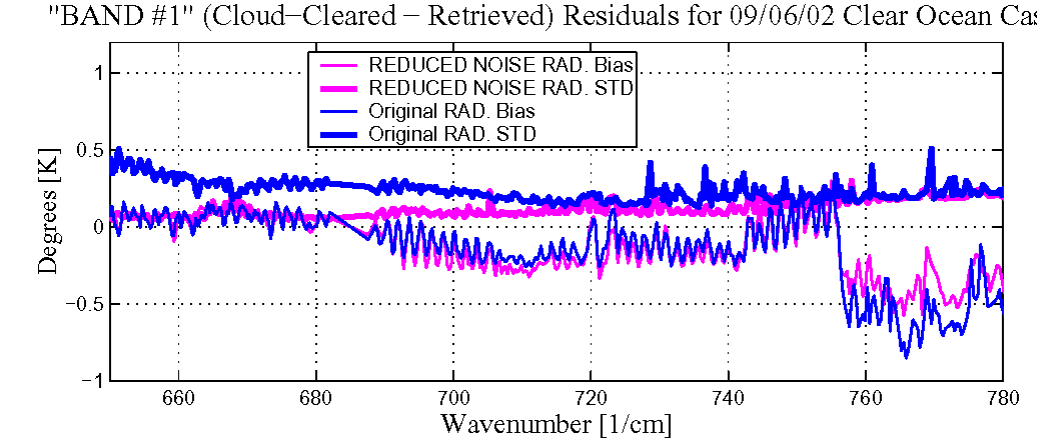
Used old channel noise (certainly not optimal)

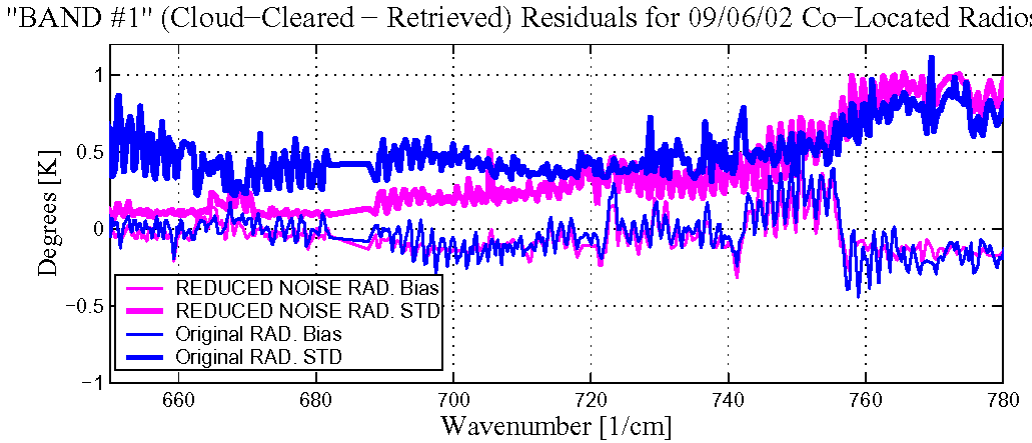
Otherwise, used latest baseline system

Regression matrix based on September 6 data only

Use of combined September 6, January 25 data produces more stable matrix


"BAND #1" Original RAD. BTs for 09/06/02 Co−Located Radiosondes
Degrees [K]
300
280
260
240
220
200
660
680
700
720
740
760
780
Wavenumber [1/cm]


"BAND #1" (Cloud−Cleared − Retrieved) Residuals for 09/06/02 Clear Ocean Cases
REDUCED NOISE RAD. Bias
REDUCED NOISE RAD. STD
Original RAD. Bias
Original RAD. STD
Degrees [K]
1
0.5
0
−0.5
−1
660
680
700
720
740
760
780
Wavenumber [1/cm]


"BAND #1" (Cloud−Cleared − Retrieved) Residuals for 09/06/02 Co−Located Radiosondes
REDUCED NOISE RAD. Bias
REDUCED NOISE RAD. STD
Original RAD. Bias
Original RAD. STD
Degrees [K]
1
0.5
0
−0.5
−1
660
680
700
720
740
760
780
Wavenumber [1/cm]

FUTURE EXPERIMENTS WITH REDUCED NOISE RADIANCES

Approach works best at frequencies less than 750 cm^{-1}

Transformation at higher frequencies may suffer from inadequacies in retrievals

- surface spectral emissivities
- surface and cloud spectral bi-directional reflectance
- upper tropospheric water
- ozone profiles

We will attempt to use noise reduced radiances at low frequencies only

- Incorporate and test use of transformed channel noise covariance matrix
- Perform experiments with different “tuning error” matrix
- Reassess rejection tests and thresholds
  - May be more sensitive to outliers with lower noise covariance